Natural Gas – Friend or Foe of the Environment? Evaluating the Framing Contest Over Natural Gas Through a Public Opinion Survey in the Pacific Northwest

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Ethics Review
This research was reviewed and declared exempt by the Institutional Review Boards at The Evergreen State College (Protocol #1819-046) and Oregon State University (Protocol# IRB-2019-0183).

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A fierce debate is raging about the role of natural gas in North America's energy mix. Once viewed as a bridge fuel for renewable energy, it is increasingly being characterized as hindering the energy transition. We explore public opinions about natural gas, its use and export, among residents in Oregon, Washington and British Columbia. While many of our respondents supported the continued use of natural gas in electricity generation and viewed it as relatively environmentally friendly, they did not feel that the benefits of fracking (increasingly the main source of natural gas production) outweigh its risks. Males, political conservatives, those who prioritized the economy over the environment, and those who didn't subscribe to anthropogenic global warming felt more favorably toward natural gas. Furthermore, those who saw gas as more environmentally friendly were more supportive of gas usage and export, while those with pro-environmental views were less likely to support it.

Keywords: public opinion, natural gas, framing, survey research

Introduction

Natural gas is familiar to much of the public, long consumed in homes for heating and cooking. Over the last decade, it has become a cheap and abundant energy source - owing to technological advances in hydraulic fracturing and directional drilling (Wang et al. 2014). This, coupled with a growing emphasis on reducing carbon emissions, has prompted the retirement of coal-fired electricity plants in favor of natural gas (Burney 2020). Meanwhile, energy companies are investing in major export infrastructure in both

the U.S. and Canada, including pipelines and export terminals to compress natural gas into Liquified Natural Gas (LNG), which can be exported by ship to lucrative overseas markets.

Natural gas is often touted as a more environmentally friendly fossil fuel than coal or oil (Natural Resources Canada 2020b) and a 'bridge fuel' toward a cleaner energy future (Casselman 2009; Paraskova 2019). Proponents argue that it has a lower carbon footprint and should replace coal-fired electricity production until renewable energy infrastructure proliferates to dominate the grid. Opponents argue natural gas is still a fossil fuel and burning it produces greenhouse gas (GHG) emissions. Moreover, its extraction and transportation can result in leaks of methane, an even more powerful GHG than carbon dioxide (Zeke Hausfather 2015; Zake Hausfather 2016; Howarth 2014; Howarth, Santoro, and Ingraffea 2011). As such, natural gas is seen by opponents as a 'bridge to nowhere,' with further investment considered a 'gangplank' for climate action (Fox 2013; Ingraffea 2013). Yet, we know little about how the public views these debates about natural gas.

Using a 2019 quota survey of residents of the Canadian providence of British Columbia and the U.S. states of Oregon and Washington, we gauge the relative predominance of proponent and opponent frames about natural gas by examining 1) public beliefs about the environmental benefits and harms of natural gas, 2) the factors that help predict how individuals view natural gas, and 3) the relationship between these views and support for using and exporting natural gas.

This region provides an ideal location for studying perceptions of natural gas. While Washington has no natural gas production and Oregon has very little, British Columbia is a major producer (Hughes 2018), and the B.C. government actively frames increasing natural gas development as an important climate solution (Stephenson, Doukas, and Shaw 2012). There have also been numerous proposals to construct large LNG storage and export facilities in the Pacific Northwest to ship natural gas to overseas markets. In British Columbia, 13 LNG export facilities have been proposed, with one built and one currently under construction (Natural Resources Canada 2020a). In Oregon, two controversial LNG export proposals have occurred in recent years, with one being given the green light under the Trump administration after being rejected under Obama (Boudet, Baustad, and Tran 2018; Boudet, Trang, and Gaustad 2017; Hazboun and Boudet 2018; Pierce et al. 2018). In Washington, an LNG storage and bunkering facility proposed by the regional utility was approved in 2019 and has been permitted for construction; activists worry it will facilitate LNG export in the future (Cockrell 2019). These proposed developments have led to news coverage and public debate around natural gas development broadly and its export specifically. This controversy, coupled with the progressive and pro-environmental politics of this region, make it a fruitful laboratory in which to study public perceptions about the environmental character of natural gas.

Review of Relevant Research

Framing natural gas: An evolving debate

The ongoing debate around whether natural gas is clean or dirty – bridge or gangplank – can be understood as a framing contest, played out by various actors on the discursive field of energy policy and politics (Snow 2004). The concept of 'framing' refers to the societal process of producing and assigning meanings. This idea relies upon the belief that "meanings do not automatically or naturally attach themselves to the objects, events, or experiences we encounter, but often arise, instead, through interactively based interpretive processes" (Snow 2004, p. 384). That is, meaning making is a social, cultural, and political process, played out within various discursive fields and led by different sets of actors, including social movement and countermovement leaders (Benford and Snow 2000), the media (Koopmans and Olzak 2004), political elites (Brulle, Carmichael, and Jenkins 2012), and industry (Plec and Pettenger 2012), among others.

Meaning-making is an ongoing process, subject to the broader historical and cultural contexts in which it occurs. Interested parties respond to discursive opportunities that arise and potentially open pathways to gain leverage in the project of convincing interest groups or wider society to adopt certain frames (Koopmans and Statham 1999). The evolving historical, social, and political context has been conceptualized as the 'discursive opportunity structure,' which is thought to shape the relative success of different framing efforts, yet "the contours of the playing field can change in an Alice-in-Wonderland fashion in the middle of the contest because of events that lie beyond the control of the players" (Gamson 2004; p. 249).

The framing of natural gas as a 'cleaner' fossil fuel than coal, and thus one that can help society transition or 'bridge' to a renewable future, has been around since the 1970s (Commoner 1979). The 'bridge fuel' frame was supported by industry, government, and environmentalists alike. The natural gas industry has long engaged in a public relations campaign to promote its product, which has included influencing the public to adopt natural gas stoves and emphasizing the lower carbon dioxide emissions of natural gas compared with other fossil fuels, but without mentioning methane emissions (Leber 2021). Additionally, in the 2000s, many major environmental groups such as the Sierra Club, as well as prominent environmentalists, advocated for using natural gas to get off coal (Kennedy Jr. 2009; Sheppard 2012).

More recently, the 'bridge fuel' frame has become contested, and new frames have emerged. Delborne et al.'s (2020) analysis of the presence of natural gas frames in U.S. news articles and government publications identified two additional natural gas frames that have arisen since the late 1980s: the 'renewable facilitator' and 'bridge to nowhere' frames. The 'renewable facilitator' frame proposes that natural gas is a useful and necessary component of a largely renewable energy system. This frame relies on the assertion that renewable energies like solar and wind are inherently unreliable, and thus need a fossil fuel companion to fill in gaps when the sun isn't shining and the wind isn't blowing. In this view, natural gas is preferred to coal because it is a lower carbon form of energy and because it can be more quickly fired up when it's needed (compared with coal, which takes longer to 'ramp up' or 'ramp down'). However, as opposition to natural gas – and specifically hydraulic fracturing – has risen, especially in the last decade, the

concept of natural gas as a 'bridge to nowhere' has become increasingly prominent, especially amongst environmentalists and liberals. The 'bridge to nowhere' frame views natural gas as a dead end for climate action and the environment.

A growing social movement has gained traction over the last decade that seeks to constrain the global supply of all fossil fuels, including natural gas (Piggot 2018; Carter and McKenzie 2020). Sometimes identified as the "leave it in the ground" (LINGO) or "keep it in the ground" (KIIG) movement, proponents argue against gas as a 'bridge fuel' since this requires significant investments in new infrastructure. They argue such investments translate at best into stranded assets as climate policies limiting fossil fuels consumption take hold, or at worst into continued motivation to delay climate action (Berg 2019; Erickson, Lazarus, and Piggot 2018; Lazarus and van Asselt 2018; LINGO 2019; Piggot et al. 2020). Instead, this capital could go toward 'electrification of everything,' which could then be powered by renewable energy (DiChristopher 2020; Staddon and Depledge 2015; Stephenson and Shaw 2013; Union of Concerned Scientists 2015). Along these lines, progressive municipalities across the country are enacting ordinances that ban natural gas hookups in new construction and require complete electrification of new homes and other buildings in hopes this will further speed the transition to a renewable energy grid (Mingle 2020).

Yet today, major players in the political and energy sphere continue to envision a future in which natural gas plays a substantial, long-term role in energy production and economic growth worldwide. In Canada, Prime Minister and Liberal Party leader Justin Trudeau has been known for his 'balancing act' between pushing to cut GHG emissions

while also promoting the fossil fuels industry, including natural gas development and export (Gardner 2019; Tindall, Stoddart, and Howe 2020). Meanwhile, under the Trump administration, the U.S. adopted an "energy dominance" framework for energy policy in which fossil fuels extraction and export were heavily encouraged (DiChristopher 2017). Now, the future of natural gas consumption and export in the U.S. is unclear under Democratic president-elect Joe Biden (Clark and Anchondo 2020).

The debate over how to view natural gas is ongoing, evolving, and intensifying. Yet, how the public has received these competing framing efforts is not clear.

Public Attitudes about natural gas, hydraulic fracturing, and natural gas export

Much of the research on public opinions of natural gas focuses specifically on the use of hydraulic fracturing to extract oil and gas, with less research examining general public support for natural gas consumption relative to other energy sources or its exportation. Generally, studies suggest that the public is more supportive of using natural gas to produce electricity than coal or nuclear but less supportive of gas than renewables (Ansolabehere and Konisky 2009; 2012; Brunner and Axsen 2020; Hazboun and Boudet 2020; Kreuze, Schelly, and Norman 2016; Sherren et al. 2019; Stoutenborough, Shi, and Vedlitz 2015). A recent poll by Pew Research Center indicated that significant majorities of Americans (72%) and Canadians (66%) are in favor of expanding natural gas as an energy source (Funk et al. 2020). Some research has suggested that Americans view natural gas as less harmful to the environment than other fossil fuels (Ansolabehere and Konisky 2012; Lacroix et al. 2020) but also envision a decarbonized future with a decreasing role of natural gas (Leiserowitz 2020; Miniard, Kantenbacher, and Attari

2020). A recent experimental study suggests that the term itself, "natural gas," contributes to positive attitudes toward it, whereas calling the same substance "methane" or "methane gas" engenders more negative perceptions (Lacroix et al. 2020).

Hydraulic fracturing is highly controversial, though individuals' knowledge and awareness of the technology is mixed (Borick & Clarke, 2016; Boudet et al., 2014; Thomas et al., 2017). As with other energy sources (Boudet, 2019), public opinion on fracking is highly tied to its perceived risks and benefits (Borick and Clarke 2016; Kreuze, Schelly, and Norman 2016; Lee and Clark 2020; Thomas et al. 2017). Opponents highlight localized environmental, social, and public health impacts (Mayer 2016), as well as emissions contributions to global climate change (Clarke et al. 2019; Evensen and Brown-Steiner 2018). Proponents emphasize the economic opportunities brought by shale gas development, the advantages of a domestically produced energy source, and the perception that natural gas is a cleaner fuel with less emissions than coal and oil. Interestingly, studies have found that it's not rare for individuals to hold seemingly contradictory views - that is, they might simultaneously agree with the risks of fracking but also emphasize its benefits (Ladd, 2014; Mayer, 2016).

Certain factors help predict public support and risk attitudes toward hydraulic fracturing, natural gas consumption more generally, and natural gas export. Both political ideology and political party affiliation are closely related to public views on fossil fuels use, with Republicans and conservatives being more supportive of using fossil fuels (Gravelle and Lachapelle 2015; H. Boudet et al. 2014; Pierce et al. 2018) than Democrats and liberals. In the US, the two-party political system could account for some of the

extreme polarization on energy issues. As a counter to the U.S. example, a recent study of individuals living in European Union countries found that political ideology was only a minor factor in predicting citizen policy priorities relevant to energy (Tosun and Mišić 2020). However, research from Canada – a three-party country – found significant political divisions on hydraulic fracturing, with political conservatives being far more supportive (O'Connor and Fredericks 2018). In general, political ideology is found to be a consistent predictor with respect to hydraulic fracturing and fossil fuels export (Boudet et al., 2014; Clarke & Evensen, 2019; Davis & Fisk, 2014; Hazboun, 2019; Pierce et al., 2018), yet is more mixed when measuring general support for natural gas (Hazboun and Boudet 2020; Sherren et al. 2019). Residence in or near communities or regions that produce natural gas is associated with a higher likelihood of support for shale gas (Boudet et al., 2016; Boudet et al., 2018; Brunner & Axsen, 2020), though political ideology can moderate the impact of proximity (Clarke et al. 2016). Individuals' environmental and climate change attitudes have also generally been found to be significant predictors of opinion about natural gas and hydraulic fracturing (Brunner and Axsen 2020; Hazboun and Boudet 2020). In addition, sociodemographic characteristics, such as gender, education, income, and age have been found in some studies to relate to support (Boudet et al., 2014, 2016, 2016; Boudet, 2019; Clarke et al., 2015).

There are two gaps in previous research relevant to the present project. First, it's unclear how connected public views on hydraulic fracturing are with general attitudes about natural gas use, even though a majority of natural gas consumed in the U.S. (75%) and Canada (over 50%) is extracted from tight shale plays via hydraulic fracturing (U.S.

EIA 2020) and this proportion is projected to increase (Hughes 2018; U.S. EIA 2019). Second, it's unclear how or to what extent individuals think about the climate change implications of natural gas when forming their attitudes about its consumption, extraction practices, and overseas export (Clarke et al. 2019; Evensen and Brown-Steiner 2018). In fact, very few studies have examined this specifically (Christenson, Goldfarb, and Kriner 2017; Evensen and Brown-Steiner 2018; Whitmarsh et al. 2015). More commonly, climate change attitude is tested as a causal variable in regression models predicting attitudes (Hazboun and Boudet 2020). One recent study examining this found that public concern about the climate impacts of shale gas was a relevant but less salient concern than water quality, air quality, and fish and wildlife habitat (Evensen and Brown-Steiner 2018). Furthermore, the authors found that many respondents (42%) didn't know if shale gas increased or lowered emissions, 36% thought shale gas lowered emissions, and 21% thought it increased emissions. More research is needed to parse out public understanding of natural gas.

We explore the following research questions using five original measures framing natural gas's impact on the environment: 1) Which frames of natural gas are most salient, and for which political groups? 2) How strongly do different attitudes about natural gas relate to one another; specifically, do views on fracking align with views on the climate impacts of natural gas? 3) What factors relate to viewing natural gas as more environmentally friendly? 4) Does viewing natural gas as environmentally friendly predict support for its continued usage and export?

Data and Methods

Sampling, matching, and weighting procedure

        We contracted YouGov to recruit an online quota sample and administer our survey,[i] requesting 500 respondents from Oregon, Washington, and British Columbia with equal amounts from rural and urban counties/districts. YouGov interviewed 690 respondents for Oregon, 760 respondents for Washington, and 794 respondents for British Columbia (2224 total) and then reduced the sample to 1500 respondents using a matching and weighting procedure based on a sampling frame of gender, age, race, and education to produce the final sample.[ii] For Oregon and Washington, the sampling frame was constructed using stratified sampling from the full 2017 American Community Survey (ACS) 1-year estimates using selection within strata by weighted sampling with replacements. For British Columbia, the frame was constructed using stratified sampling from the 2012 full Canada Internet Usage Survey sample using selection within strata by weighted sampling with replacements. YouGov included sampling weights in the final dataset, and these are used in the analysis.[iii] To ensure data quality, YouGov removed or replaced respondents who indicated a patterned mode of response, sped through the survey and/or failed an attention-check question.

Measurement

        We measured seven primary variables relevant to natural gas, including two items aimed at assessing general attitudes toward both natural gas use and export and five statements about environmental frames for natural gas (Table 1). We included two measures related to respondents' environmental views – one assessed their belief in anthropogenic global warming and one measured whether they would prioritize the

environment over the economy or vice versa. Additionally, because political views are such a consistent predictor of public views on environment, climate, and energy, we included a measure of political ideology.[iv] We also measured a variety of sociodemographic factors, used as controls in our regression models, including gender, age, race, education, residence in a metro/urban or non-metro/rural county, and state/providence of residence.

[Table 1 near here]

Analysis

We address our first three research questions by analyzing comparative descriptive results for the seven dependent variables, parsed by political ideology. We then report pairwise correlations between these seven measures to examine the consistency of respondents' views of natural gas. We then compile the natural gas framing measures into a summated rating scale (*enviro_gas*) and interrogate this for dimensionality and internal reliability. Last, we present a series of regression models to examine our third and fourth research questions.

Results

Which natural gas frames are most salient, and for which political groups?

Figure 1 presents weighted summary statistics for the seven natural gas variables, parsed by political ideology. The first variable, measuring support for natural gas usage, indicates relatively high support, with 62% of respondents indicating they would like to keep the amount of natural gas used for electricity at status quo or increased levels. There is a stark difference between political groups, with 43% of liberals and 85% of

conservatives indicating support. In contrast, just under half of respondents (49%) indicated support for natural gas export. Export is similarly politically polarized, with only 30% of liberals and 72% of conservatives indicating support.

[Figure 1 near here]

We turn next to the framing measures: 67% of respondents overall agreed that natural gas was better for the environment than other fossil fuels, 61% felt it was a bridge fuel to a renewable future, and 60% agreed that natural gas produces less GHG than other fossil fuels. More than half of liberals supported each of the three positively worded environmental frames (62%, 54%, and 55%); conservatives and moderates were even more supportive. These three measures were far less politically polarizing than support for natural gas consumption and export – liberals were only 9-16 percentage points lower than conservatives.

The two negatively worded framing measures were far more politically polarizing. While 45% of respondents overall felt the benefits of natural gas were not worth the methane leaks that occurred from producing it, only 22% of conservatives (and 34% of moderates) agreed with this statement, while 66% of liberals agreed. For the measure about hydraulic fracturing, notably more respondents overall (57%) agreed that the benefits gained from hydraulic fracturing of natural gas are not worth the impacts; yet, there was a 46-percentage-point spread between liberals and conservatives (76% of liberals, 53% of moderates, and 30% of conservatives agreed).

Overall, frames that viewed natural gas positively and more environmentally friendly (and which were not connected to hydraulic fracturing) had the most support and least political polarization.

How strongly do different attitudes about natural gas relate to one another?

Pairwise correlations between the seven natural gas variables (Table 2) reveal that the two support variables (gas usage and export) are moderately positively correlated, with a Pearson's r value of 0.506. Additionally, these two variables are moderately and positively correlated with two of the positive environmental framing measures (better for environment: 0.435 and 0.402; bridge fuel: 0.447 and 0.446), though less strongly correlated with the less GHG emissions frame (0.369 and 0.319). However, the two negative environmental frames were moderately and negatively correlated with support for gas usage and export (methane leaks: -0.466 and -0.502; fracking concerns: -0.438 and -0.486).

[Table 2 near here]

The pairwise correlations between the five framing measures reveal that respondents' concerns about hydraulic fracturing were only weakly related to their views about the environmental attributes of natural gas (better for environment: -0.278; bridge fuel: -0.287; less GHG: -0.214). However, fracking concerns and concerns about methane leaks were strongly and positively correlated (0.624), suggesting that methane leaks might be one of the primary reasons why opposed respondents were concerned about fracking. The three positively worded environmental framing questions were all moderately to strongly correlated with one another, with the strongest association

between the idea that natural gas is better for the environment and the idea that it produces less GHG than other fossil fuels (0.620). This suggests that the climate impacts of natural gas are at the top of mind for many respondents when weighing its environmental attributes.

Constructing a rating scale to measure environmental view of natural gas

We conducted a factor analysis of the five natural gas framing measures to examine the potential for compiling a summated rating scale, with the two negatively worded framing statements reverse-coded (Table 3). We used principal factor extraction and found that the five items were reliable as one coherent scale – the singular factor had an eigenvalue of 2.1, and all items had factor loadings well above 0.4. Additionally, the Cronbach's alpha for the set was 0.773 and all items had sufficiently high item-rest correlations (0.48 to 0.60). Respondents scores on these five measures were summed to produce a new variable, called the *enviro_gas* scale (range=5 to 25; mean=15.87; sd=4.38). A higher score on the scale suggests greater agreement with an environmentally friendly framing of natural gas.

[Table 3 near here]

What factors relate to viewing natural gas as more environmentally friendly?

Assessing predictors of respondent scoring on the *enviro_gas* scale using weighted ordinary least squares regression (Table 4), we find that of our sociodemographic factors the gender variable stands out as the strongest predictor of scoring higher on the enviro_gas scale, with male respondents scoring on average 1.75 points higher on the *enviro_gas* scale than females, all else being equal (Model 1).

Respondents with a bachelor's degree scored on average 0.81 points lower than those without. Age, race, residence in an urban (vs. rural) area, and state of residence were not significant.

[Table 4 near here]

In Model 2, we added the categorical political ideology variable. Moderates on average scored 2.22 points higher than liberals on the *enviro_gas* scale, while conservatives scored 3.99 points higher than liberals, all else being equal. Additionally, the effect of being male was only slightly weakened but remained significant, while residence in either Washington or Oregon (compared to British Columbia) contributed, on average, a point increase in the dependent variable.

In Models 3 and 4, we add prioritization of environment over economy and belief in anthropogenic warming. Both these variables were statistically significant, negative predictors of agreeing with an environmental framing of natural gas. In Model 3, respondents who said they would prioritize the environment over the economy scored on average 3 points lower on the *enviro_gas* scale than those who answered opposite. In Model 4, those who said they believed warming was mostly human-caused scored 1.9 points lower on the scale than those who did not.

Across all models, the effects of being male as well as living in Washington or Oregon are relatively consistent. Political ideology is also consistent, though attenuated in the final model once the environmental and warming variables are added. Last, the model quality metrics (R-squared and AIC) indicate that the modeling is improved with each variable added.

Does viewing natural gas as environmentally friendly predict support?

We turn next to the regression models predicting respondents' support for natural gas usage (Table 5) and natural gas export (Table 6). We used logistic regression with a binary outcome variable in these models, and odds ratios are reported.[v]

[Table 5 and Table 6 near here]

Of the sociodemographic variables, being white as opposed to non-white was a statistically significant negative predictor of support for natural gas usage. Age was statistically significant but the practical effect very small. The largest effect was the political ideology variables: compared to liberals, moderates had over two and a half times higher odds of support, and conservatives had over six and a half times higher odds.

In Model 2, the continuous *enviro_gas* scale variable is added to the model and is significant, with the odds of support for natural gas usage increasing by 25% as respondents' scores on the *enviro_gas* scale increase by one point. Adding the *enviro_gas* variable to the model conditions the influence of the political ideology variables – that is, once environmental views about natural gas are accounted for, moderates had 82% higher odds of support and conservatives had just over three times higher odds of support, compared to liberals. The odds ratios for the rest of the independent variables stay relatively consistent, though the statistical significance of being white disappears.

Models 3 and 4 substitute the addition of the *enviro_gas* variable for the environment versus economy variable (Model 3) and the belief in anthropogenic warming variable (Model 4); this allows us to see the influence of these two

environmental attitude variables independent of environmental views about natural gas. Both variables have similar negative effects. Respondents who said they would prioritize the environment over the economy had odds of supporting natural gas that were over 70% lower than those would who prioritize the economy, and respondents who thought warming was mostly anthropogenic had odds of support that were over 60% lower than those who did not. The effect of political ideology remains consistent in both models, as do the sociodemographic variables.

In the last model, the three environmental variables are added to explore their relative influence. While the odds ratios for the sociodemographic variables are very similar to the previous models, the effect of political ideology is attenuated, with the odds ratio for moderates losing statistical significance and the odds ratio for conservative dropping from 3.627 to 2.048. The predictive value of the *enviro_gas* scale remains unchanged from Model 2, even when accounting for respondents' other environmental attitudes. However, the effect of environmental priority and global warming beliefs are both mediated in this final, full model – the statistical significance of believing in anthropogenic warming disappears completely, while the odds ratio for prioritizing the environment remains significant but changes from 0.288 to 0.531, indicating a weakened effect.

Model quality metrics (pseudo R-squared[vi] and AIC) indicate that models that include the *enviro_gas* variable perform best – with the highest pseudo R-squared and lowest AIC value.

A somewhat different story emerges from the binary logistic regression models predicting support for natural gas export (Table 6). First, the effect of being male remains consistently strong and positive across all five models – males as compared with females have around two times higher odds of supporting natural gas export. The second notable effect is place of residence, with those living in Washington or Oregon (as compared to British Columbia) having odds of support that are 65-75% lower. The third difference is that for export believing in anthropogenic global warming remains strong, negative, and statistically significant across all models. Last, the effect of political ideology drops out completely once the three environmental attitude variables are added in the last model. Yet, in the models predicting both support for natural gas usage and natural gas export, the *enviro_gas* scale and environmental priority variables remain consistently significant across all models. As in Table 5, model quality metrics suggest that models with the *enviro_gas* variable have the best explanatory power.

Discussion and conclusion

Our descriptive findings suggest that a strong majority (67%) of our respondents perceive natural gas as a relatively environmentally friendly fossil fuel, with 61% viewing it as an appropriate 'bridge fuel' to an energy system dominated by renewables and 60% believing it emits less GHG than other fossil fuels. We also found most respondents supported the continued or expanded use of natural gas in electricity generation (62%), though there was significantly less support for exporting it (49%). Simultaneously, respondents were quite concerned about hydraulic fracturing, with 57% agreeing that the impacts of fracking were 'not worth it.' As most of the natural gas

production in the U.S. and Canada is achieved through hydraulic fracturing, this suggests a possible point of public misunderstanding. It also suggests the power and pervasiveness of the environmental framing of natural gas for electricity generation.

Males, political conservatives, those who prioritized the economy over the environment, and those who didn't believe that global warming was anthropogenic were significantly more likely to see natural gas as an environmentally friendly(er) fossil fuel. Furthermore, those who agreed natural gas is more environmentally friendly had significantly higher odds of supporting natural gas usage and export, while those who prioritized the environment over the economy and believed anthropogenic warming was occurring were less likely. Respondents from British Columbia were significantly more likely to support natural gas export than those from Washington or Oregon. One possible explanation for this is that British Columbia is a major natural gas producer.

In terms of how respondents' views on hydraulic fracturing related to their views on natural gas, we found that respondents on average were both supportive of natural gas us and thought it was environmentally friendly, yet also thought hydraulic fracturing was not worth the impacts. For example, 358 respondents (24%) said they agreed that the benefits gained from hydraulic fracturing were not worth the impacts yet also supported continued or expanded use of natural gas for electricity generation. Similarly, 521 respondents (35% of our sample) agreed that the benefits of natural gas are not worth the methane leaks that occur from producing it yet also supported its continued or expanded use for electricity generation. In many ways, our findings suggest that many individuals

simultaneously view natural gas as better than coal for electricity generation but are concerned about the impacts of fracking.

As expected, responses on all the natural gas variables varied by political ideology, with moderates and conservatives being much more supportive of natural gas usage and export than liberals but much less likely to agree that hydraulic fracturing or methane leaks from natural gas extraction are problematic. The narrowest gaps between political groups occurred in the three positively worded environmental framing variables – liberals, moderates, and conservatives had much more similar levels of agreement that natural gas is better for the environment, is a bridge fuel, and produces less GHG. Yet, conservatives, moderates, and liberals had statistically different scores on the summed *enviro_gas* scale, with conservatives scoring on average over 4 points higher than liberals on this scale.[vii] This suggests that conservatives were the most likely to agree with the environmental benefits of natural gas and the least likely to worry about its environmental harms.

Delborne and colleagues (2020) found that the framing of natural gas as a 'bridge fuel' became notably less widespread after 2010, with other frames competing for prominence, such as the idea that natural gas is a 'bridge to nowhere.' However, our research suggests that the 'bridge fuel' frame is alive and well in the Pacific Northwest region of the U.S. and Canada, as is the broader notion that natural gas is better for the environment than other fossil fuels. Furthermore, our results found relatively high support for the continued use of natural gas in electricity production. Yet, our respondents exhibited significant concern about hydraulic fracturing and methane leaks

from natural gas extraction. Overall, we have identified a vital tension in the framing contest over natural gas, which will undoubtedly continue to play out in national and regional media coverage, opposition organizing by environmental groups, industry efforts, and policy decisions for years to come. The framing contest for natural gas is seemingly far from decided.

Political elites and the energy narratives they espouse are likely to continue to influence the public, if not to further entrench polarized views of energy topics (Mayer 2019). In the U.S., president-elect Joe Biden has promised an emphasis on climate mitigation and a reining in of fossil fuels, yet it's unknown how much actual change in energy policy his presidency will enact. In Canada, Prime Minister Trudeau (who won reelection in 2019) promotes a climate-friendly policy framework yet promotes the development and export of fossil fuels, including natural gas.

At a more local level, awareness of natural gas's harmful environmental impacts will be spotlighted by the increasing number of municipalities around the country pushing for complete electrification through ordinances banning natural gas hookups in new buildings. And furthermore, the market itself may be a factor in public perception of natural gas in the years ahead, with increasing prices possibly dampening the enthusiasm for gas as a stable, major source of electricity in the long run (J. Lee 2020).

Some limitations of our study are worth acknowledging. First, our data were drawn from a quota sample rather than a probability sample – even with the complex matching and weighting procedure used in the construction of the sample, as well as the post-weighting, we do not claim our data to be fully representative of the target

population. Second, our study covers one region of two large and diverse countries.

Comparative and national-level research would help greatly to understand how public

opinion on natural gas varies by region and between the U.S. and Canada. Third, as is

often employed in framing research, we do not rely on an experimental design to test how

different frames for natural gas influence public opinion. This type of experimental

design would be an important next step for future research.

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Table 1. Descriptive statistics for all variables (n=1500)

Variable	*Question Wording & Response Options*	*Mean (SD) or Frequency (n)*
Male	Are you male or female? (1) Male; (0) Female	42.2% (633) Male
Age	In what year were you born? (Subtracted from survey year, 2019). Range=18 to 94	53.4 (16.2)
White	What racial or ethnic group best describes you? (1) White; (2) Black; (3) Hispanic/Latino; (4) Asian; (5) Native American; (6) Mixed; (7) Other	84.5% (1,267) White, non-Hispanic
Bachelors	What is the highest level of education you have completed? (1) 4-year college degree [bachelors]; (0) Less than 4-year college degree	40.1% (602) Bachelors
Metro	Respondents' county classified as metro or nonmetro	50% (750) Metro
Ideology	In general, how would you describe your own political viewpoint? (1) Very liberal; (2) Liberal; (3) Moderate; (4) Conservative; (5) Very conservative. *Variable collapsed to 3 categories for analysis.*	43.9% Liberal, 28.4% Moderate, 27.6% Conservative

EnvEcon	With which one of these statements do you most agree? (1) Protection of the environment should be given priority, even at the risk of curbing economic growth; (0) Economic growth should be given priority even if the environment suffers to some extent.	72.5% (1,087) Environment
Anthro	Assuming global warming is happening, do you think it is: (1) Caused mostly by human activities; (0) Not caused mostly by human activities	51.7% (775) Human activities
Support gas usage	For each power source listed below, indicate whether you feel [the U.S./Canada] should REDUCE or INCREASE its use [Natural Gas]. (1) Reduce a lot; (2) Reduce somewhat; (3) Keep same; (4) Increase somewhat; (5) Increase a lot	15.0% (224) Reduce a lot; 22.3% (334) Reduce somewhat; 31.1% (465) Keep same; 21.8% (327) Increase somewhat; 9.8% (147) Increase a lot
Support gas export	Exporting fossil fuels involves transporting these fuels over land from their point of extraction, typically via railroad or pipeline, to an export terminal for processing and transfer to a ship for transport overseas. To what extent do you OPPOSE or SUPPORT [the U.S. / Canada] exporting the following fossil fuels to other countries? [Natural Gas (for example, as LNG)] (1) Strongly oppose; (2) Somewhat oppose; (3) Not sure; (4) Somewhat support; (5) Strongly support	24.8% (371) Strongly oppose; 19.7% (295) Somewhat oppose; 9.8% (146) Not sure; 24.0% (359) Somewhat support; 21.8% (326) Strongly support

Better for environment	Natural gas is better for the environment than other fossil fuels. (1) Strongly disagree; (2) Somewhat disagree; (3) Not sure; (4) Somewhat agree; (5) Strongly agree	5.6% (84) Strongly disagree; 11.1% (166) Somewhat disagree; 17.6% (264) Not sure; 45.1% (677) Somewhat agree; 20.6% (309) Strongly agree
Methane leaks	The benefits of natural gas are not worth the methane leaks that occur from producing it. (1) Strongly disagree; (2) Somewhat disagree; (3) Not sure; (4) Somewhat agree; (5) Strongly agree	11.3% (170) Strongly disgaree; 23.5% (352) Somewhat disagree; 18.0% (270) Not sure; 23.9% (358) Somewhat agree; 23.3% (349) Strongly agree
Bridge fuel	Natural gas serves as a bridge fuel to a renewable energy future. (1) Strongly disagree; (2) Somewhat disagree; (3) Not sure; (4) Somewhat agree; (5) Strongly agree	7.0% (105) Strongly disagree; 14.1% (212) Somewhat disagree; 18.1% (272) Not sure; 41.7% (626) Somewhat agree; 19.0% (285) Strongly agree

Less GHG	Burning natural gas produces less greenhouse gas than other fossil fuels. (1) Strongly disagree; (2) Somewhat disagree; (3) Not sure; (4) Somewhat agree; (5) Strongly agree	4.7% (70) Strongly disagree; 9.9% (148) Somewhat disagree; 24.9% (374) Not sure; 41.4% (621) Somewhat disagree; 19.1% (287) Strongly agree
Fracking concerns	The benefits gained from hydraulic fracturing of natural gas are not worth the impacts. (1) Strongly disagree; (2) Somewhat disagree; (3) Not sure; (4) Somewhat agree; (5) Strongly agree	9.6% (144) Strongly disagree; 14.3% (215) Somewhat disagree; 17.4% (261) Not sure; 19.3% (289) Somewhat agree; 39.4% Strongly agree

Notes: Unweighted variable means reported.

Table 2. Pairwise correlations for natural gas attitude variables

	1.	2.	3.	4.	5.	6.	7.
1. Support gas usage	1.000						
2. Support gas export	0.506	1.000					
3. Better for environment	0.435	0.402	1.000				
4. Methane leaks	-0.466	-0.502	-0.368	1.000			
5. Bridge fuel	0.447	0.446	0.563	-0.394	1.000		
6. Less GHG	0.369	0.319	0.620	-0.316	0.478	1.000	
7. Fracking concerns	-0.438	-0.486	-0.278	0.624	-0.287	-0.214	1.000

Notes: Pearson's r product-moment correlation coefficients reported. All coefficients were statistically significant at the p<0.001 level.

Table 3. Factor analysis for natural gas environmental framing measures

	Factor 1	Uniqueness
Better for environment	0.72	0.40
Methane leaks (reversed)	0.65	0.44
Bridge fuel	0.66	0.55
Less GHG	0.65	0.50
Fracking concerns (reversed)	0.55	0.51
Eigenvalue	*2.1*	
% variance explained	*98.7%*	

Notes: Unrotated factor loadings shown. Principal factor extraction. Only factors with eigenvalues >1 were retained.

Table 4. Weighted OLS regression models predicting respondents' scores on the *enviro_gas* scale

Variable	Model 1	Model 2	Model 3	Model 4
Male	1.751***	1.605***	1.514***	1.644***
Age	0.059***	0.039***	0.038***	0.034***
White	-0.486	-0.487	-0.532	-0.312
Bachelors	-0.808*	-0.258	-0.206	-0.112
Metro	0.107	0.494	0.188	0.369
State *(ref=BC)*				
Washington	-0.648	-1.156**	-1.103	-1.198***
Oregon	-0.856	-1.062**	-0.856*	-0.875*
Ideology *(ref=Liberal)*				
Moderate		2.216***	1.539***	1.081*
Conservative		3.992***	2.254***	1.398**
EnvEcon			-3.060***	-2.351***
Anthro				-1.925***
_cons	13.323***	12.506***	15.570***	16.247***
n	1,499	1,378	1,377	1,377
R-squared	0.109	0.255	0.332	0.361
AIC	8474	7565	7412	7354

*Notes: Standardized regression coefficients reported. *p<0.05, **p<0.01, ***p<0.001*

Table 5. Weighted binary logistic regression models predicting respondents' support for natural gas usage (odds ratios)

	Model 1	Model 2	Model 3	Model 4	Model 5
Male	1.340	0.995	1.329	1.452	1.054
Age	1.026***	1.019**	1.026***	1.024***	1.020**
White	0.574*	0.624	0.545*	0.645	0.626
Bachelors	0.798	0.811	0.814	0.840	0.836
Metro	1.216	1.116	1.111	1.298	1.123
State (ref=BC)					
Washington	0.664	0.865	0.690	0.638	0.840
Oregon	0.658	0.863	0.728	0.666	0.883
Ideology *(ref=Liberal)*					
Moderate	2.609***	1.819*	2.120**	2.026**	1.559
Conservative	6.653***	3.188***	3.527***	3.627***	2.048*
Envirogas scale		1.251***			1.219***
EnvEcon			0.288***		0.531*
Anthro				0.386***	0.704
_cons	0.398*	0.020***	1.319	0.746	0.066***
n	1,376	1,375	1,375	1,376	1,374
Pseudo R-squared	0.145	0.235	0.174	0.168	0.245
AIC	1584	1421	1533	1544	1404

*Notes: Odds ratios reported. *p<0.05, **p<0.01, ***p<0.001*

Table 6. Weighted binary logistic regression models predicting respondents' support for natural gas export (odds ratios)

	Model 1	Model 2	Model 3	Model 4	Model 5
Male	2.305***	1.653*	2.335***	2.729***	1.903**
Age	1.010	0.999	1.011	1.007	1.000
White	0.624	0.669	0.591	0.703	0.678
Bachelors	0.844	0.833	0.861	0.917	0.896
Metro	1.354	1.221	1.165	1.500	1.239
State (ref=BC)					
Washington	0.296***	0.348***	0.292***	0.254***	0.312***
Oregon	0.273***	0.312***	0.292***	0.250***	0.306***
Ideology *(ref=Liberal)*					
Moderate	3.199***	2.049**	2.451***	2.200**	1.541
Conservative	6.833***	2.884***	3.032***	2.835***	1.332
Envirogas scale		1.338***			1.285***
EnvEcon			0.216***		0.471*
Anthro				0.227***	0.449**
_cons	0.469	0.011***	2.103	1.308	0.067***
n	1,377	1,376	1,376	1,377	1,375
Pseudo R-squared	0.1698	0.2965	0.2188	0.2219	0.3236
AIC	1602	1361	1509	1504	1312

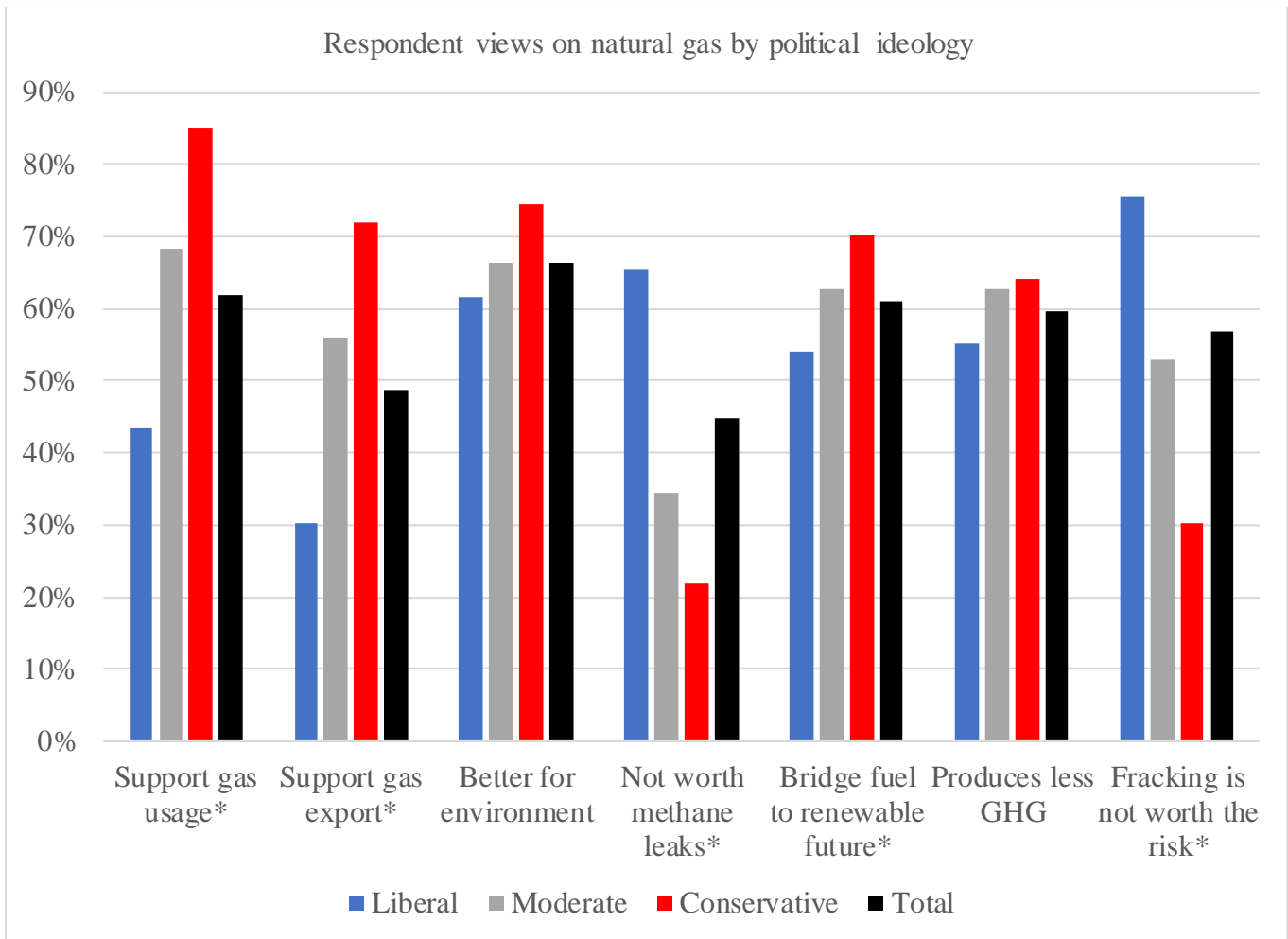*Notes: Odds ratios reported. *p<0.05, **p<0.01, ***p<0.001*

Figure 1. Weighted responses to seven questions measuring support for using natural gas, support for exporting natural gas, and agreement with environmental statements about natural gas, by political ideology. Variables with an asterisk indicate statistically significant differences between political categories as determined by a weighted Pearson's chi-squared test of difference.

Endnotes

[i] Online administration is increasingly widespread in contemporary survey research, especially given declining response rates to mail, telephone, and in-person survey modes (Stedman et al. 2019). Online vendors like YouGov maintain large respondent pools and can obtain the desired number of responses through their proprietary on-line platform, then use quota sampling, sample weighting, and other strategies to ensure that a nonprobability sample best approximates a probability sample.

[ii] The matching and weighting procedure used a propensity score function that included age, gender, race/ethnicity, years of education, region, and metro/non-metro. The propensity scores were grouped into deciles of the estimated propensity score in the frame and post-stratified according to these deciles.

[iii] For Oregon and Washington, the weights were post-stratified first using 2016 Presidential vote choice and a four-way stratification of gender, age (4-categories), race (4-categories), and education (4-categories), then on metro/non-metro distribution from the November 2018 Current Population Survey (CPS) to produce the final weights. For British Columbia, the weights were first post-stratified on a four-way stratification of gender, age (4-categories), race (4-categories), and education (4-categories), and then on metro/non-metro distribution from 2018 Census.

[iv] Political ideology is a more complicated construct in Canada than in the United States. For example, the Liberal Party is a federal, left-of-center (liberal) political party in Canada, while the British Columbia Liberal Party is right-of-center (conservative) political party in the providence of B.C. Our measure asked respondents to self-rate on a five-point political

ideology scale from Very Liberal to Very Conservative; as such, we were cautious in the interpretation. Our results suggested our respondents interpreted the question as we intended – our B.C. respondents who answered as "conservative" were more likely to support natural gas usage and export, as were our U.S. respondents.

[v] We used (weighted) logistic regression for our second and third regressions, since the dependent variables in these models are ordinal variables. We originally estimated ordered logistic regression; however, these models violated the proportional odds assumption, also called the parallel regression assumption (Brant 1990). Thus, we collapsed the dependent variables into binary measures of support and estimated binary logistic regression models instead.

[vi] McFadden's R2 is often used in logistic regression models to indicate the amount of variation in the dependent variable accounted for by the predictor variables. McFadden states that pseudo R2 values in the range of 0.2–0.4 indicate quite a high amount of variation explained and "excellent" model fit. However, McFadden himself warned that this (rho-squared) indicator produces values that are "considerably lower than those of the R2 index [in OLS regression]" (McFadden 1979).

[vii] Though we did not report this in our results, we ran a weighted one-way Analysis of Variance (ANOVA) to determine that conservatives, moderates, and liberals had statistically different scores on the *enviro_gas* scale.